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6 INTERNAL COCKPIT REFLECTIONS OF EXTERNAL POINT LIGHT SOURCES FOR THE MODEL YAH-64 ADVANCED ATTACK HELICOPTER

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INTRODUCTION

The US Army Human Engineering Laboratory (HEL) has developed a computer program for computing internal cockpit reflections on the transparent canopy surfaces of external point light sources. This work is part of a three-stage effort to determine optimum canopy designs for the Model 209 AH-1S Cobra Helicopter and the Model YAH-64 Advanced Attack Helicopter (AAH). This work was undertaken at the request of the Project Manager's Office, USA Aircraft Survivability Equipment. The low glare canopy design presently used on both models consists of flat, transparent panels on the front surfaces and simple cylindrical panels on the sides and top. The design is a reasonable choice for reducing both solar glint to outside cbservers during daytime operations and internal reflections of outside light sources during nighttime operations.

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A flat plate canopy (FPC) design was originally developed for the Cobra and AAH to reduce daytime solar glint to a momentary flash at certain observer-aircraft-sun angles. A moving aircraft no longer produced the continual solar glint which was present on the earlier compound-shaped canopy designs. The continual presence of solar glint had increased the range of visual detection by ground observers.

However, in certain lighting situations during nighttime operations, the internal surfaces of the FPC performed as mirrors reflecting virtual images of external light sources that were visible to the pilot. HEL has shown by computer analysis that these reflections are possible on most of the transparent surfaces and for a wide range of source locations (1). These virtual images of ground-level lights were disorienting to the pilot and he could not easily discriminate between the light sources on the ground and their reflections from the canopy surfaces. This problem was a potential safety hazard during flight.

The present low glare canopy design was developed to reduce these two conflicting problems to manageable levels. The design incorporates front planar transparent surfaces and simple cylindrical surfaces for the sides and top. HEL recommended a similar design with, however, novel features (2). The present this work effort is directed toward a closer study of the two problems of glint and reflections, and developing an optimum design for the canopy's transparent surfaces.

METHOD

A ray-tracing program was written to trace in three dimensions the straight-line rays from the nominal position of the pilot's eye backwards to visible points on the internal surfaces of the cockpit. Each ray is traced between transparent surface points until a non-transparent surface is reached. These surfaces are assumed to be diffusive without specular reflectances and the ray is considered absorbed. At each reflection point on a transparent surface, the reflectance and transmittance are computed along with the directional cosines of the corresponding transmitted and reflected rays. In this way, a reflected ray reaching the pilot's eye is traced backwards to all possible external sources that can generate that ray.

The transparent surfaces of the low glare canopy design are specified as a set of planar and cylindrical surfaces and their corresponding edge vertices. Each planar surface is specified by the coordinates of its edge vertices and the consecutive order in which adjacent vertices are listed. A cylindrical surface is specified by cylindrical parameters and the consecutive sequence of the edge vertices and their coordinates. The cylindrical parameters are (1)origin point on the cylindrical axis, (2)directional cosines of the axis, and (3)the radius of the cylinder. The edges of the cylindrical surface are assumed for simplicity to be curvilinear lines which become straightened when the cylinder is transformed into a flat plane.

Given directional cosines and an origin point of a straight-line ray, the program computes, in turn, the intersection point of the ray with each surface. The program tests the intersection point against the surface edges. The reflection point for the ray is that intersection point which is contained within the edges of the corresponding

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surface segment. The angle of incidence between the surface normal and the ray at this point is computed along with the corresponding values of reflections and transmittance and the directional cosines of the transmitted and reflected rays. Tracing backwards, the reflected ray becomes the incident ray for the next set of computations. (See Appendix A of reference (1) for ray tracing on planar surfaces and computation of transmittance and reflectance values, and Appendix B of reference (3) for derivation of equations used in ray tracing on cylindrical surfaces.)

The program includes internal and external obstructing surfaces and the internal blast barrier of the YAH-64 between the pilot and copilot, as well as the transparent surfaces of the canopy in the computation. The obstructing surfaces are those that either obstruct the pilot's vision or block incident rays from external sources. The internal surfaces are (1)the pilot's seat, display panel and side armor, (2)the copilot's seat, gunner-sight and side armor, and (3)the sides and floor of the cockpit. The external surfaces are (1)aircraft nose section, (2)gun pods and wheel wells, (3)wing stubs, (4)rocket pods, (5)engine intakes, and (6) rotary housing. These surfaces are specified as planar segments in the same manner as are the canopy surfaces. The intersection computations are performed first for all obstructing surfaces and computation of a reflection point for a ray on an obstructing surface renders the computation complete since the backwards traced ray is considered absorbed.

The transparent blast barrier,which separates the copilot and pilot, is treated first as a reflecting surface and then as a transmitting surface for reflection points on surfaces beyond it.

This computation process is repeated for pilot-viewing directions indexed at equal increments over a quarter sector. The sector is bounded by vision directly to the front, to the side, top and bottom. In this way, a table is constructed which lists at discrete intervals all possible internal reflection points and the corresponding external light directions. This approach generates a large amount of data and a computer-graphics routine is included for output. The primary reflection points and the corresponding incident ray entry points are shown on side, top and front views of the canopy and on perspective drawings of the cockpit as seen from the pilot's position. Similar comments apply to computations for the copilot's position. (See Appendix C of reference (1) for a discussion of perspective drawings.)

DISCUSSION

The results of this application are shown in Figures 1 through 13. These figures are hard copies of the computer graphics output. Figure 1 shows side, top and front views of the canopy frame, blast barrier and obstructing surfaces. The pilot's nominal eye position is shown in each view. The blast barrier and obstructing surfaces are sketched in with broken lines. The aircraft fuselage and tail assembly are not included in this sketch.

Figure 2 shows side, top and front views of the canopy frame and blast barrier, sketched with broken lines, separated from the obstructing surfaces. Figure 3 is a perspective drawing of the cockpit as seen from the pilot's position. The pilot's nominal viewing direction is shown by the small cross near the top center of the upper front canopy surface. The drawing covers a 60-degree field-of-view and shows that the lower portions of the front and forward side canopy surfaces are blocked from view by the pilot's instrument panel.

The frame edges for the canopy sides are drawn as straight lines connecting adjacent corner vertices. This is done for convenience in the computer graphics routines. The computations assume that the frame edges for the cylindrical surfaces are curvilinear lines (see Method).

Figures 4 through 13 show "dots" for the entry positions of external rays generating primary reflections on the right-hand side of the canopy for the pilot's position. Also shown are the corresponding primary reflections spaced at two degrees by two degrees increments. The number shown at each reflection point is equal to the negative value of the logarithm (base 10) of the light reflectance. The numbers are truncated to their integer values by dropping the fractional parts. The numerical "zero" corresponds to those reflectances which are greater than 0.1 in value. The numerical "one" corresponds to those values equal to or less than 0.1 but greater than 0.01.

Figure 4 shows that entry points are possible over much of the lower front panel and the side surfaces. Figure 5 shows that primary reflection points can occur on (1)the upper rear corner of the front side panels, (2)the upper edge of the rear side panels, and (3)the side edges of the top panel. The front side panel reflections have reflectance values in the 0.1 to 1.0 range, while those on the rear side and top are in the 0.01 to 0.1 range.

Figures 6 and 7 are perspective drawings of the cockpit as seen from the pilot's nominal viewing position and direction. Figure 6 shows entry points on the lower front and front side surfaces. Figure 7 shows primary reflections on the right-hand side of the canopy. Figure 8 shows reflection points where the pilot has shifted his viewing direction 20 degrees to the right. (Note that some reflection points are shown on the canopy frame. This is because the structure outline is drawn as straight line members between the corner vertices instead of the curvilinear members used in the computations. See Methods.)

Figure 9 through 13 show reflection points generated on one canopy surface by external rays entering another surface. Figure 9 shows reflection points on the top surface generated by entry points on the right rear side surface. Figure 10 shows reflections on the top surface generated by entry points on the right forward side surface. Figure 11 shows reflections on the right rear side due to entry points on the left rear side. Figure 12 shows reflections on the right forward side due to entry points on the lower front surface. Finally, Figure 13 shows reflections on the right rear side due to entry points on the left forward side.

CONCLUSION

A computer program developed by HEL to show internal cockpit reflections of external point light sources has been applied to the Model YAH-64 Advanced Attack Helicopter (low glare canopy design). The results show that during nighttime operations, ground-light reflections are possible on the transparent surfaces of the canopy. Reflections are possible from the top and side canopy surfaces for the pilot and the front and forward side surfaces for the copilot. The results are an improvement over the flat plate canopy design since reflections are limited to certain portions of these surfaces. Where reflections actually occur depends upon the particular lighting situation and flight scenario.

REFERENCES

1. Smyth, C.C. Computing internal cockpit reflections of external point light sources for the Model 209 AH-1S Cobra Helicopter flat plate canopy design. Technical Memorandum 20-77, US Army Human Engineering Laboratory, Aberdeen Proving, MD, 1977.

2. Stowell, H.R., & Smyth, C.C. Investigation of inside light reflection problem on the flat plate canopy (FPC) for Model 209 AH-1S

helicopter. Technical Memorandum 13-77, US Army Human Engineering Laboratory, Aberdeen Proving Ground,MD, 1977.

3. Smyth, C.C. Computing Internal Cockpit Reflections of External Point Light Sources for the Model YAH-64 Advanced Attack Helicopter (Low Glare Design), Technical Memorandum 24-77, US Army Human Engineering Laboratory, Aberdeen Proving Ground,MD, 1977.

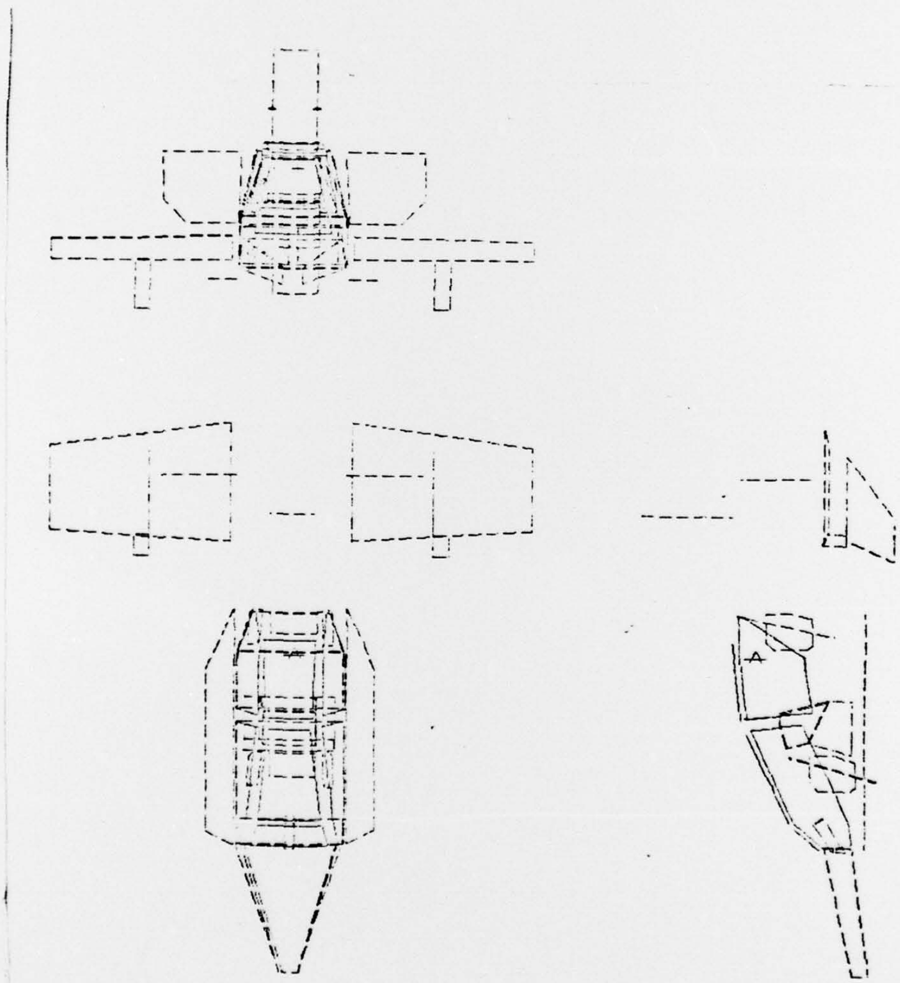

Figure 1. Top, side and front views of canopy frame and obstructing surfaces.

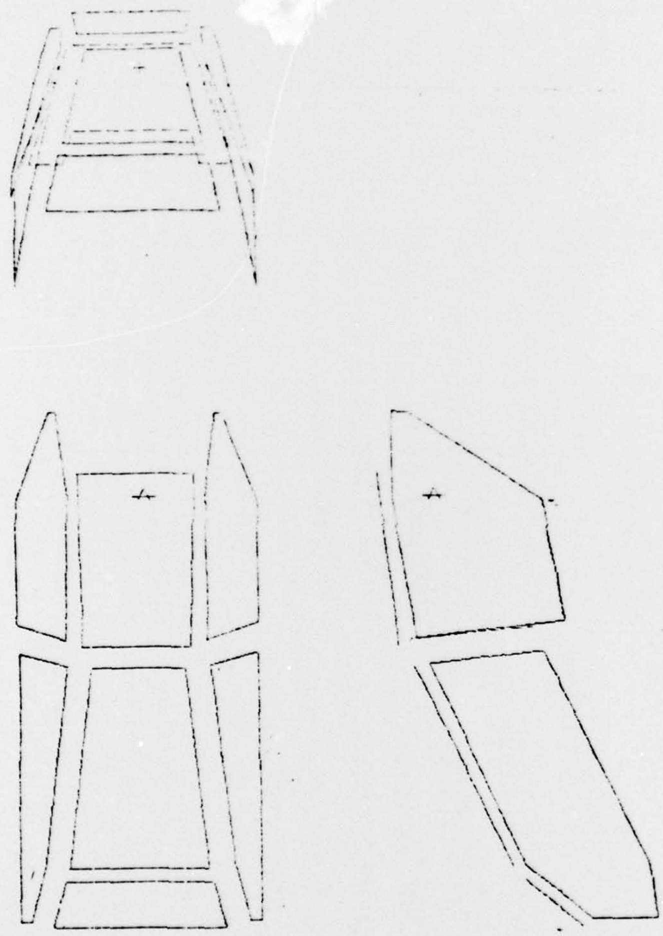

Figure 2. Top, side and front views of canopy frame.

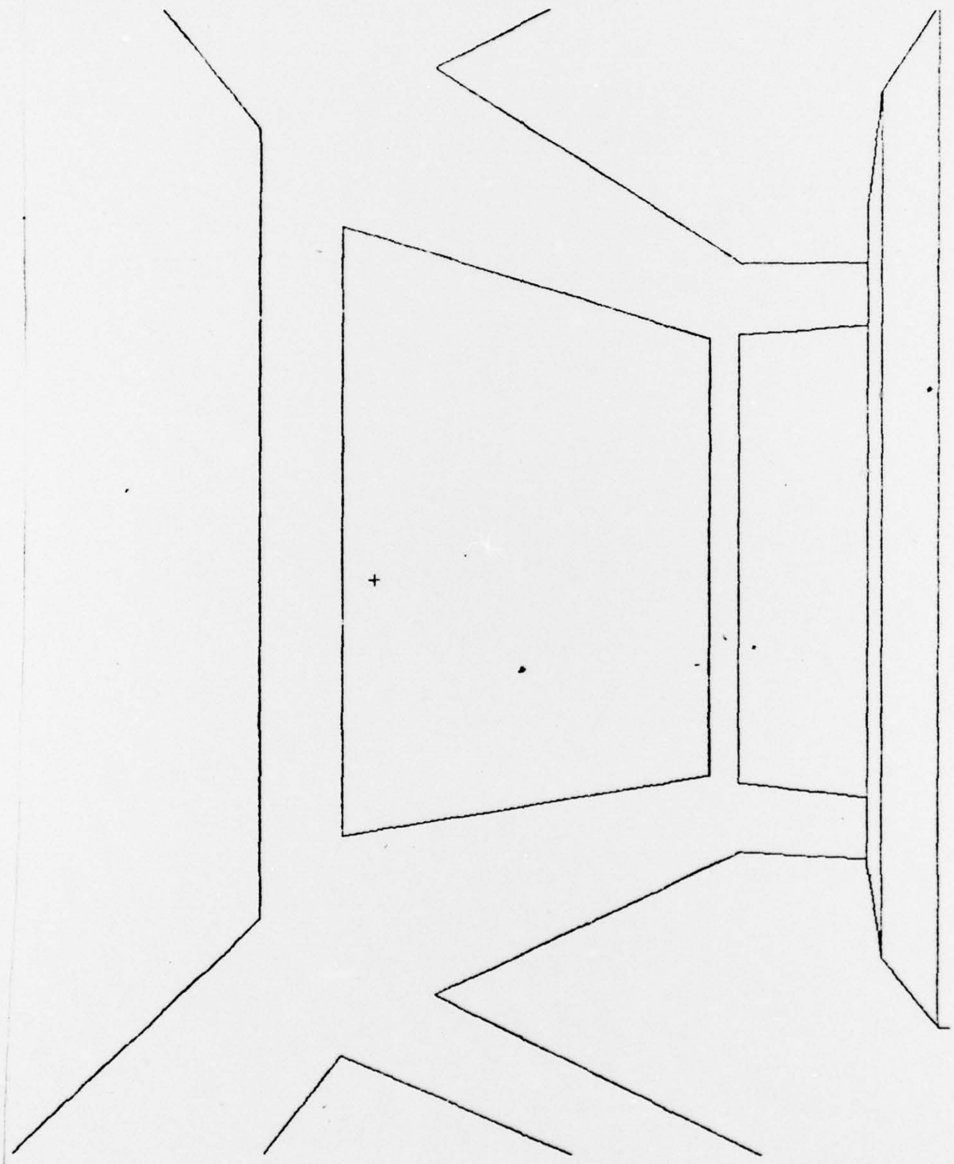

Figure 3. Perspective view of the cockpit interior from the pilot's nominal viewing position and direction.

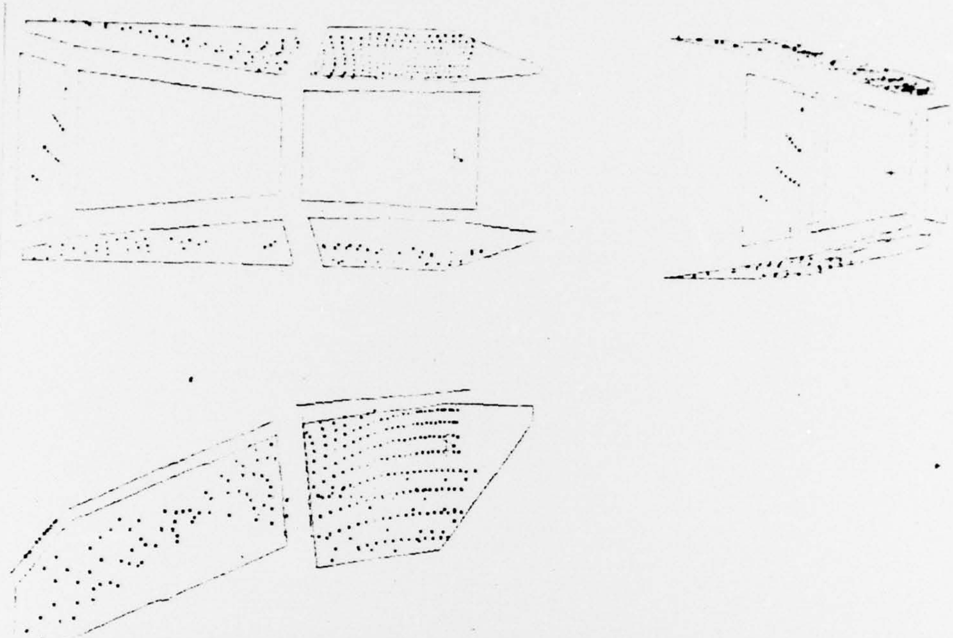

Figure 4. Entry ray positions generating primary reflections on the right-hand side of the canopy as seen from the pilot's position.

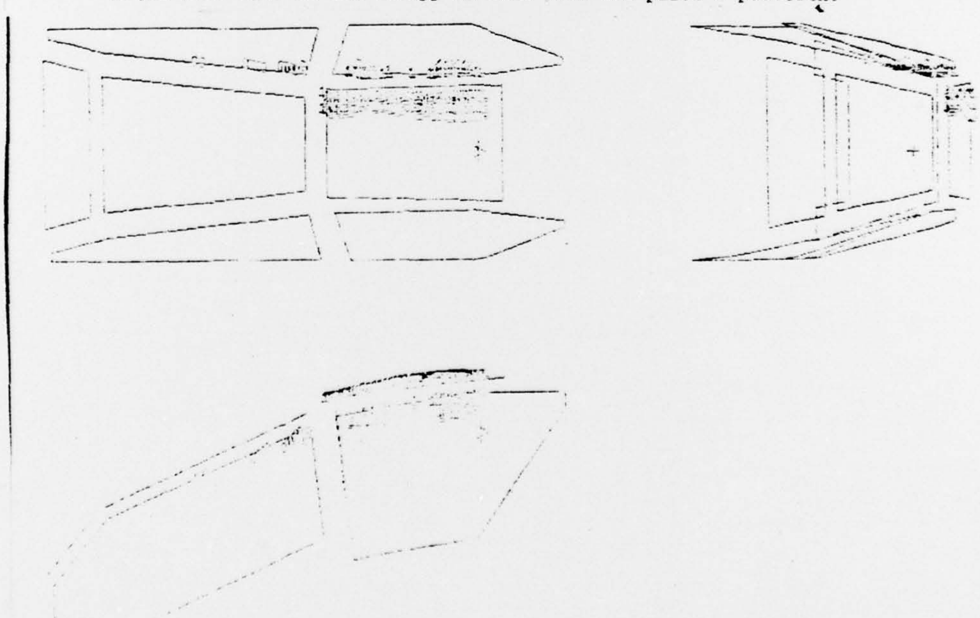

Figure 5. Primary reflection points on the right-hand side of the canopy and their associated reflectance values for the pilot's position.

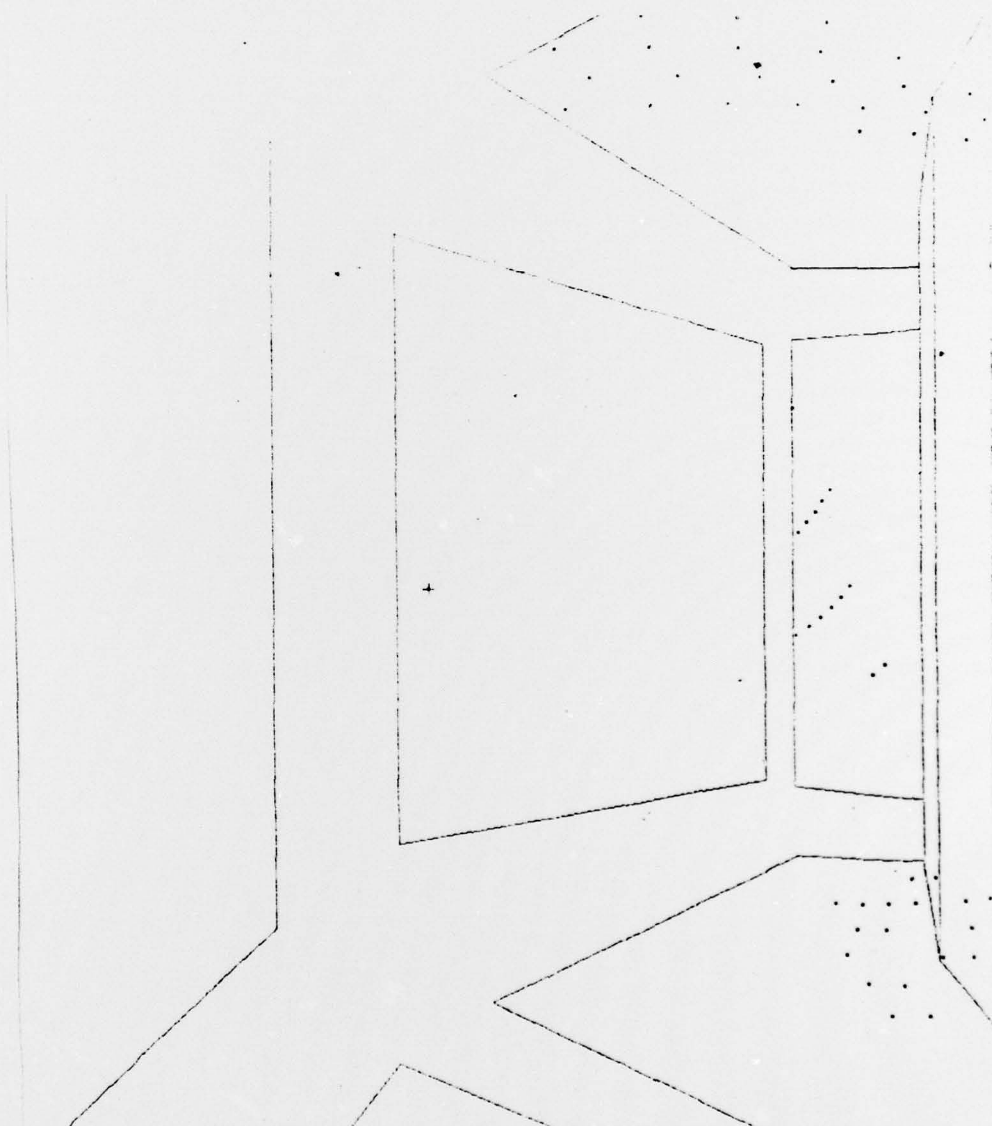

Figure 6. Perspective view of entry ray positions for the pilot's nominal viewing direction and position.

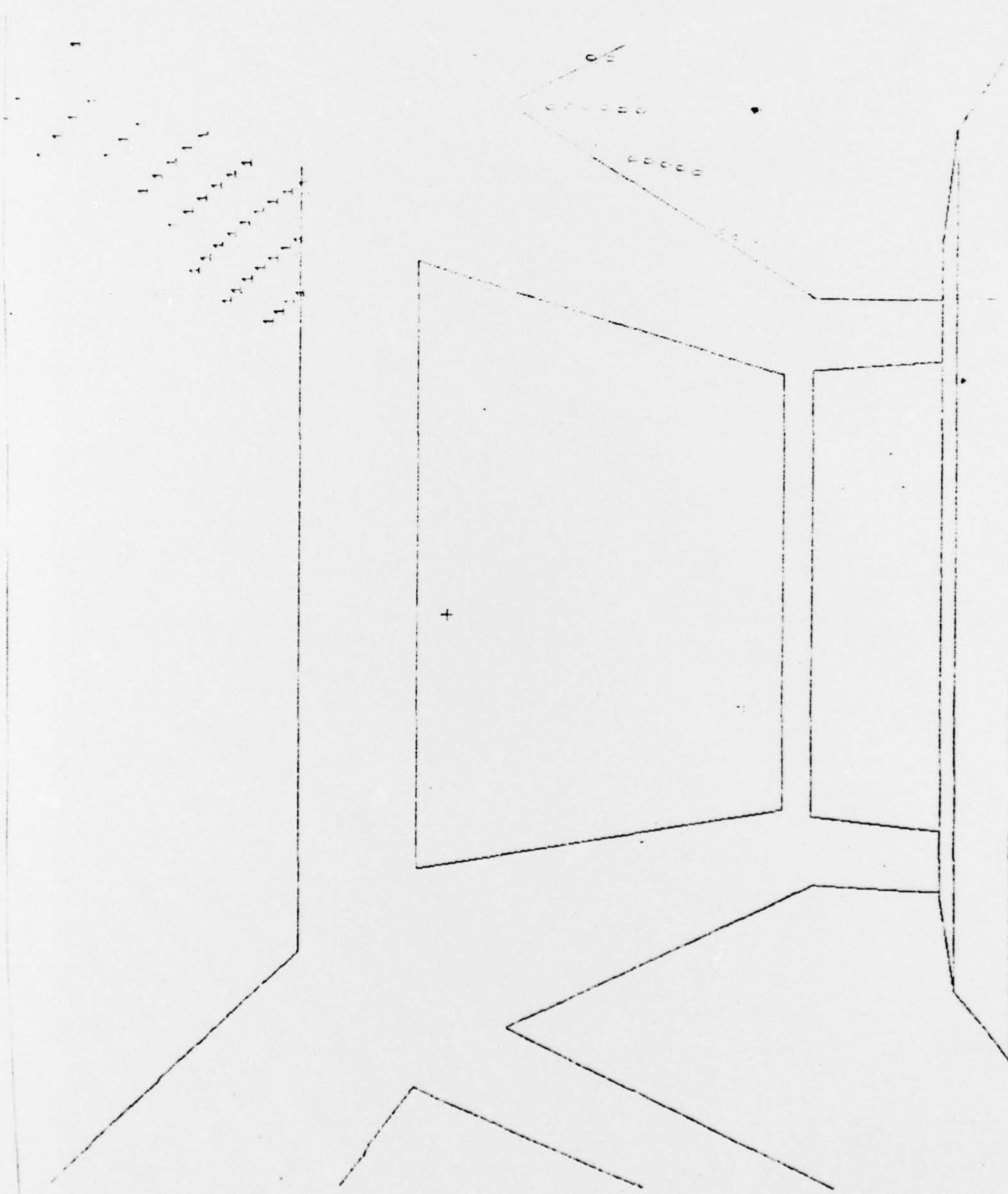

Figure 7. Perspective view of primary reflection points for the pilot's nominal viewing direction and position.

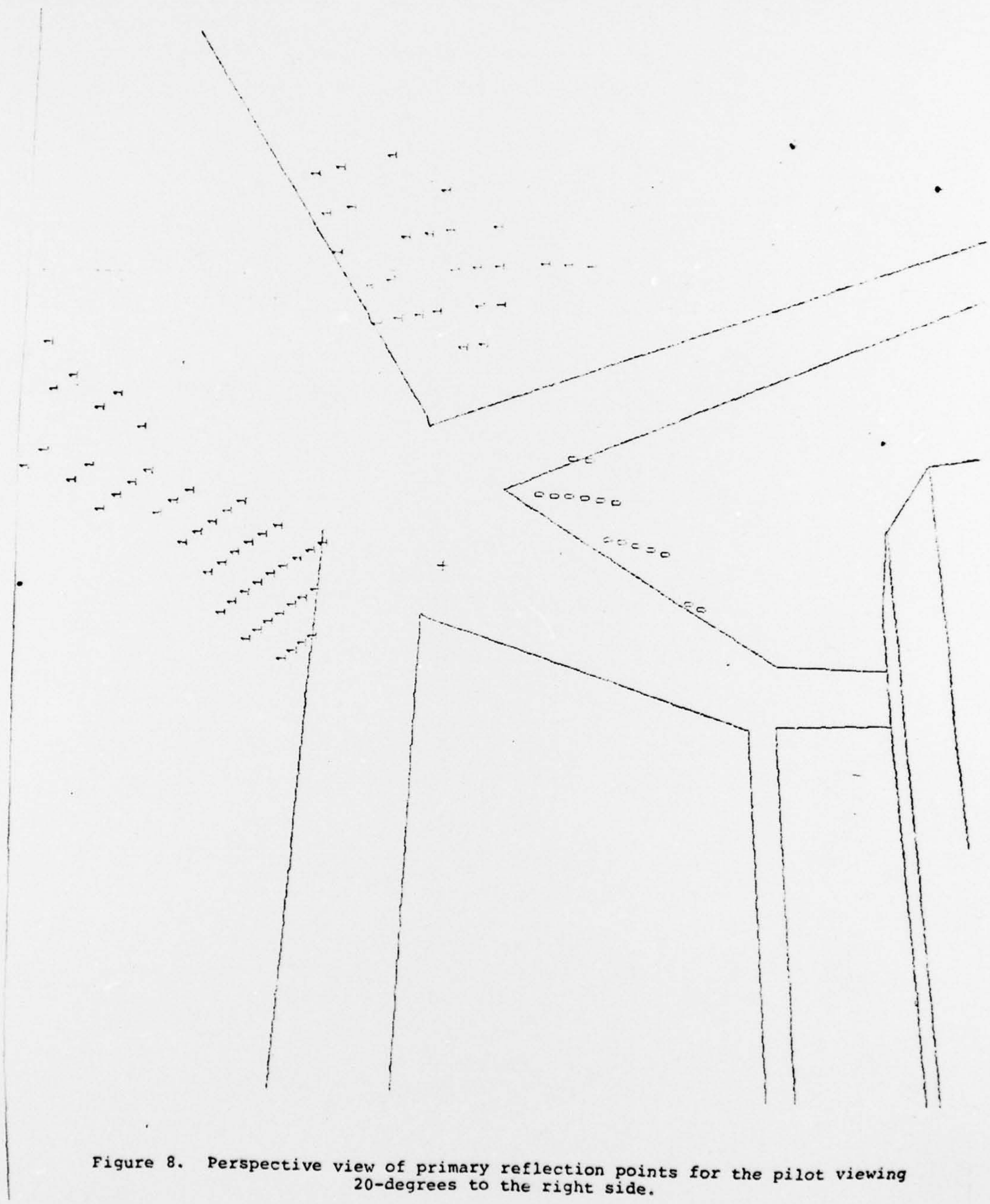

Figure 8. Perspective view of primary reflection points for the pilot viewing 20-degrees to the right side.

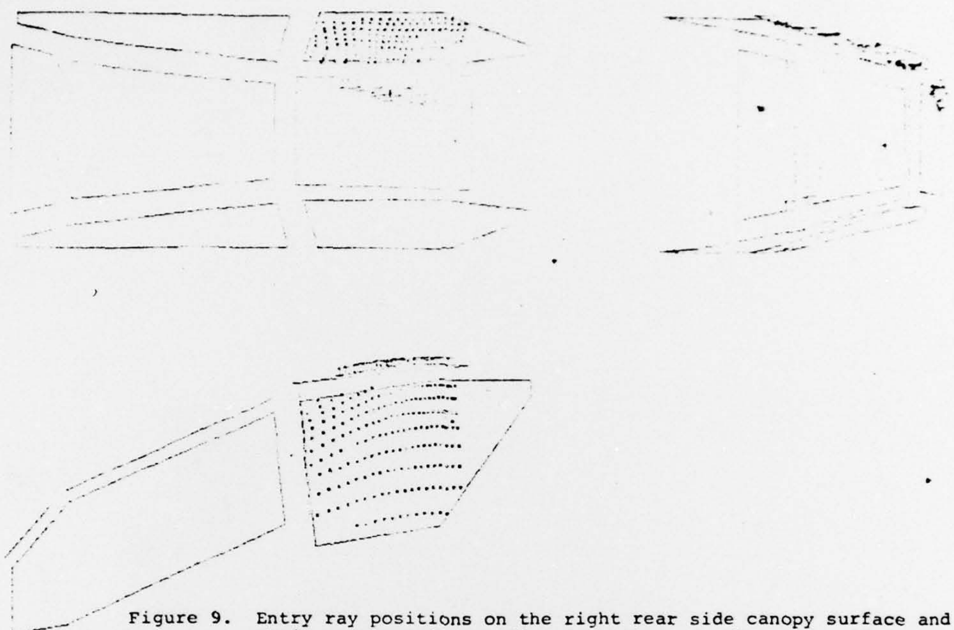

Figure 9. Entry ray positions on the right rear side canopy surface and their corresponding reflection points on the right side of the top surfaces.

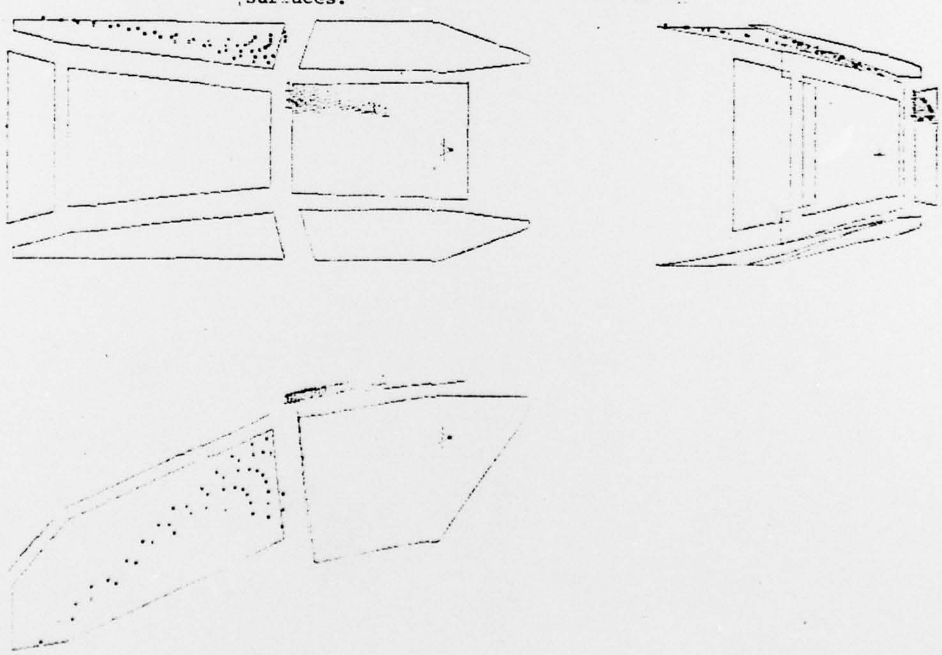

Figure 10. Entry ray positions on the right forward side canopy surface and their corresponding reflection points on the right front of the top surface.

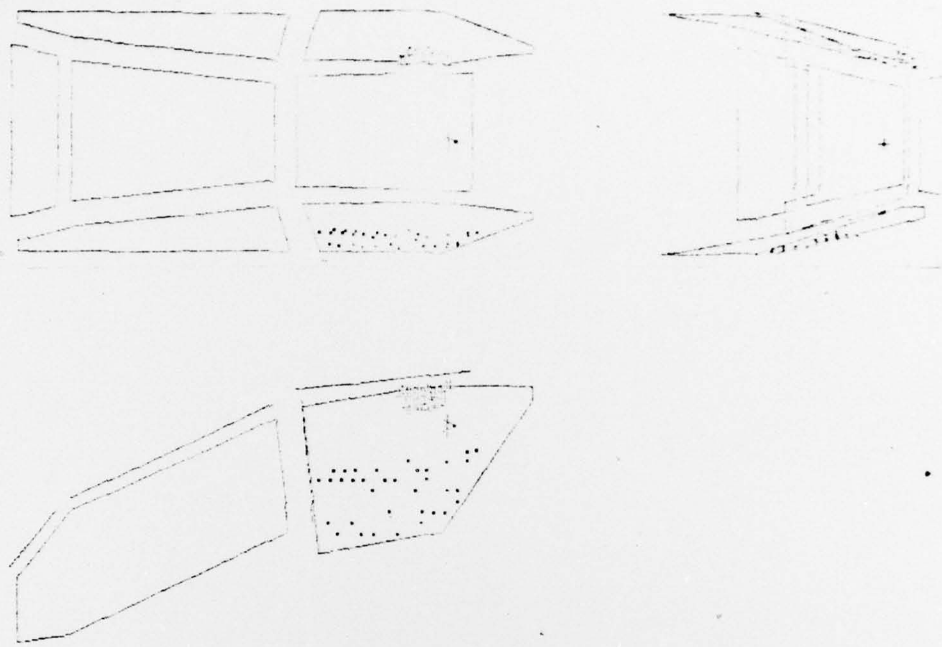

Figure 11. Entry ray positions on the left rear side canopy and their corresponding reflection points on the top edge of the right rear surface.

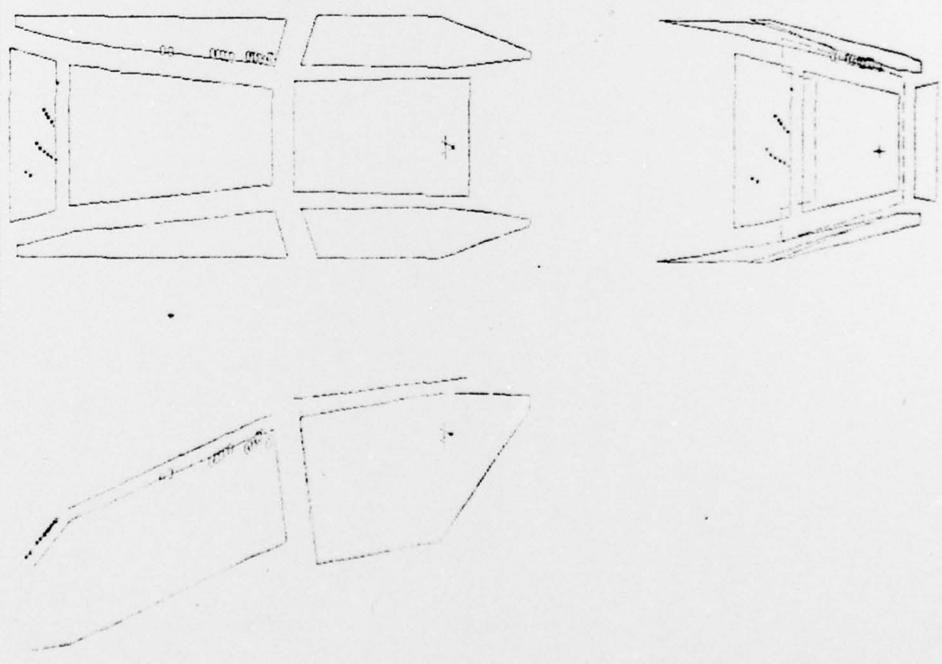

Figure 12. Entry ray positions on the lower front canopy surface and their corresponding reflection points on the upper rear corner of the right forward side surface.

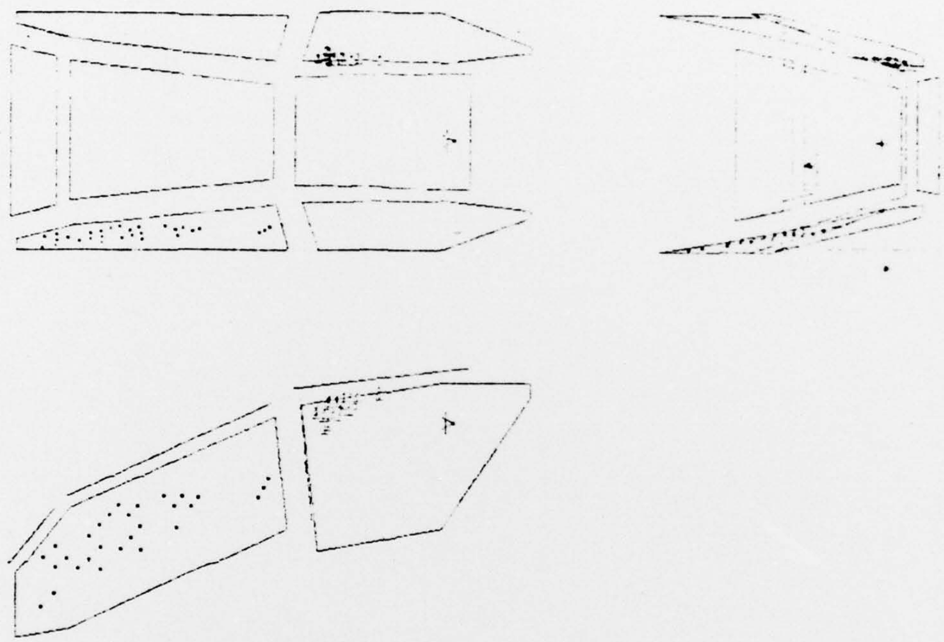

Figure 13. Entry ray positions on the left forward side canopy surface and their corresponding reflection points on the upper front edge of the right rear side surface.